WHAT IS CLAIMED IS:

Sub A1 D1

1. A method for determining at least one of motion and location parameters of a locomotive, said method comprising the steps of:

determining a set of phase differences between satellite reference signals received by satellite receivers; and

determining at least one of an accurate heading, heading rate, attitude, and attitude rate of the locomotive using the set of phase differences between the satellite reference signals.

2. A method according to Claim 1 further comprising the step of determining $\vec{\mathbf{d}}$.

3. A method according to Claim 2 further comprising the step of determining $\vec{\mathbf{d}}$ as $\vec{\mathbf{d}} = (\mathbf{H}^T\mathbf{H})^{-1}\mathbf{H}^T\vec{\mathbf{y}}$, where:

$$\mathbf{H} = \begin{bmatrix} LOS_x^1 & LOS_y^1 & LOS_z^1 \\ LOS_x^2 & LOS_y^2 & LOS_z^2 \\ \vdots & \vdots & \vdots \\ LOS_x^n & LOS_y^n & LOS_z^n \end{bmatrix};$$

$$\vec{\mathbf{y}} = \begin{bmatrix} \Delta\phi^1 - \lambda(N_1^1 - N_2^1) - c(dt_1 - dt_2) \\ \Delta\phi^2 - \lambda(N_1^2 - N_2^2) - c(dt_1 - dt_2) \\ \vdots \\ \Delta\phi^n - \lambda(N_1^n - N_2^n) - c(dt_1 - dt_2) \end{bmatrix}; \text{ and}$$

$$\vec{\mathbf{d}} = \begin{bmatrix} d_x \\ d_y \\ d_z \end{bmatrix}.$$

4. A method according to Claim 3 wherein said step of determining at least one of an accurate heading, heading rate, attitude, and attitude rate of the locomotive further comprises the step of determining an attitude and an attitude rate of a locomotive using $\vec{\mathbf{d}}$, the heading using $\tan^{-1}\frac{d_x}{d_y}$, and heading rate using $\frac{\tan^{-1} d_z}{\sqrt{d_x^2 + d_y^2}}$.

5. A method according to Claim 1 further comprising the step of determining a track curvature, C.

6. A method according to Claim 5 wherein determining a track curvature comprises the step of detecting an angular rotation rate ω and a velocity v of the locomotive, wherein C=ω / v.

7. A method according to Claim 6 wherein detecting an angular rotation rate ω and a velocity v of the locomotive comprises the step of detecting an angular rotation rate ω using a gyroscope and a velocity v of the locomotive using a tachometer.

8. A method according to Claim 6 wherein detecting an angular rotation rate ω and a velocity v of the locomotive comprises the step of detecting an angular rotation rate ω using received satellite signals and velocity v of the locomotive using a tachometer.

9. A method according to Claim 5 wherein determining a track curvature comprises the step of determining a lateral acceleration a and a velocity v of the locomotive, wherein C=a / v^2.

10. A method according to Claim 5 further comprising the step of controlling dispensing of a track lubricant in accordance with the determined curvature value C.

11. A method according to Claim 10 wherein said step of controlling dispensing of a track lubricant further comprises the step of dispensing the lubricant when *C* exceeds a predetermined magnitude.

12. A method according to Claim 1 further comprising the steps of:

determining a position of the locomotive; and

accessing a database of track heading and grade to determine a present track heading and grade at the determined position of the locomotive.

13. A method according to Claim 1 further comprising the steps of:

sampling latitude and longitude from the satellite receivers; and

determining a distance traveled by the locomotive.

14. A method according to Claim 13 wherein said step of sampling latitude and longitude from the satellite receivers further comprises the steps of:

sampling where the distance between the samples is determined as $\Delta d = R[\Delta lat^2 + \cos^2(lat)\Delta long^2]^{1/2}$

where Δlat is a difference between latitudes of consecutive measurements;

$\Delta long$ is a difference between longitudes of consecutive measurements; and

R is the radius of the earth (about 3,440 nmi); and

said step of determining a distance traveled by the locomotive further comprises the step of summing Δd over successive measurements.

15. An apparatus for determining at least one of motion and location parameters of a locomotive to detect curves and reduce track wear, said apparatus comprising:

at least two phase-locking satellite receivers configured to reference signals received from a set of satellites; and

a processor configured to determine a set of phase differences between the reference signals received by said satellite receivers and at least one of an accurate heading, heading rate, attitude, and attitude rate of the locomotive using the set of phase differences between the reference signals.

16. An apparatus according to Claim 15 wherein said processor further configured to determine $\vec{\mathbf{d}}$.

17. An apparatus according to Claim 16 wherein said processor further configured to determine $\vec{\mathbf{d}}$ as $\vec{\mathbf{d}} = (\mathbf{H}^T\mathbf{H})^{-1}\mathbf{H}^T\,\vec{\mathbf{y}}$, where:

$$\mathbf{H} = \begin{bmatrix} \mathrm{LOS}_x^1 & \mathrm{LOS}_y^1 & \mathrm{LOS}_z^1 \\ \mathrm{LOS}_x^2 & \mathrm{LOS}_y^2 & \mathrm{LOS}_z^2 \\ \vdots & \vdots & \vdots \\ \mathrm{LOS}_x^n & \mathrm{LOS}_y^n & \mathrm{LOS}_z^n \end{bmatrix};$$

$$\vec{\mathbf{y}} = \begin{bmatrix} \Delta\phi^1 - \lambda(N_1^1 - N_2^1) - c(dt_1 - dt_2) \\ \Delta\phi^2 - \lambda(N_1^2 - N_2^2) - c(dt_1 - dt_2) \\ \vdots \\ \Delta\phi^n - \lambda(N_1^n - N_2^n) - c(dt_1 - dt_2) \end{bmatrix}; \text{ and}$$

$$\vec{\mathbf{d}} = \begin{bmatrix} d_x \\ d_y \\ d_z \end{bmatrix}.$$

18. An apparatus according to Claim 17 wherein said processor further configured to determine an attitude and an attitude rate of the locomotive using $\vec{\mathbf{d}}$, the heading using $\tan^{-1}\frac{d_x}{d_y}$, and the heading rate using $\frac{\tan^{-1} d_z}{\sqrt{d_x^2 + d_y^2}}$.

19. An apparatus according to Claim 15 wherein said processor further configured to determine a track curvature, C.

20. An apparatus according to Claim 19 wherein to determine a track curvature, said processor configured to detect an angular rotation rate ω and velocity v of the locomotive.

21. An apparatus according to Claim 20 wherein to detect an angular rotation rate ω and velocity v of the locomotive, said processor configured detect an angular rotation rate ω using received satellite signals and velocity v of the locomotive using a tachometer.

22. An apparatus according to Claim 20 wherein to detect an angular rotation rate ω and velocity v of the locomotive, said processor configured detect an angular rotation rate ω using a gyroscope and velocity v of the locomotive using a tachometer.

23. An apparatus according to Claim 19 wherein to determine a track curvature, said processor further configured to:

determine a lateral acceleration a and a velocity v of the locomotive; and

determine track curvature C as: $C = a / v^2$.

24. An apparatus according to Claim 19 further comprising a device for dispensing a lubricant to a track.

25. An apparatus according to Claim 24 wherein said processor further configured to control said device dispensing the lubricant in accordance with the determined curvature value C.

26. An apparatus according to Claim 25 wherein said processor further configured to dispense the lubricant when C exceeds a predetermined magnitude.

27. An apparatus according to Claim 24 wherein said processor further configured to:

determine a position of the locomotive;

access a database of track heading and grade to determine a present track heading and grade at the determined position of the locomotive; and

control said device dispensing lubricant in accordance with a curvature value C contained within the track database.

28. An apparatus according to Claim 15 wherein said processor further configured to:

sample latitude and longitude from the GPS receivers; and

determine a distance traveled by the locomotive.

29. An apparatus according to Claim 28 wherein said processor configured to determine a distance between samples as:

$$\Delta d = R[\Delta lat^2 + \cos^2(lat)\Delta long^2]^{1/2}.$$

ADD A3